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Determining the Environmental Factors Controlling Respiration: Interpreting the Temperature Response

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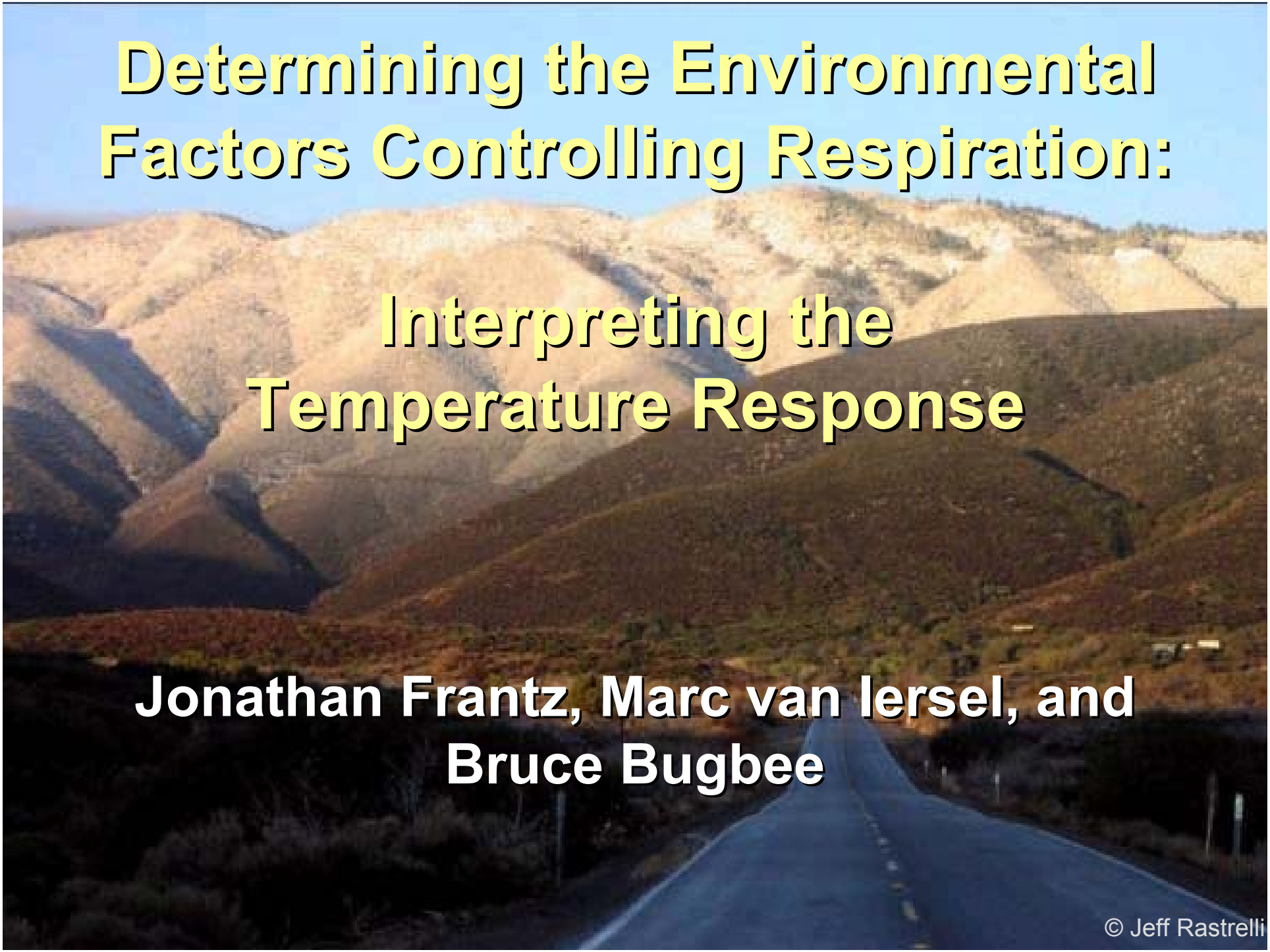
Determining the Environmental Factors Controlling Respiration:
Interpreting the Temperature Response
Jonathan Frantz, Marc van Iersel, and Bruce Bugbee
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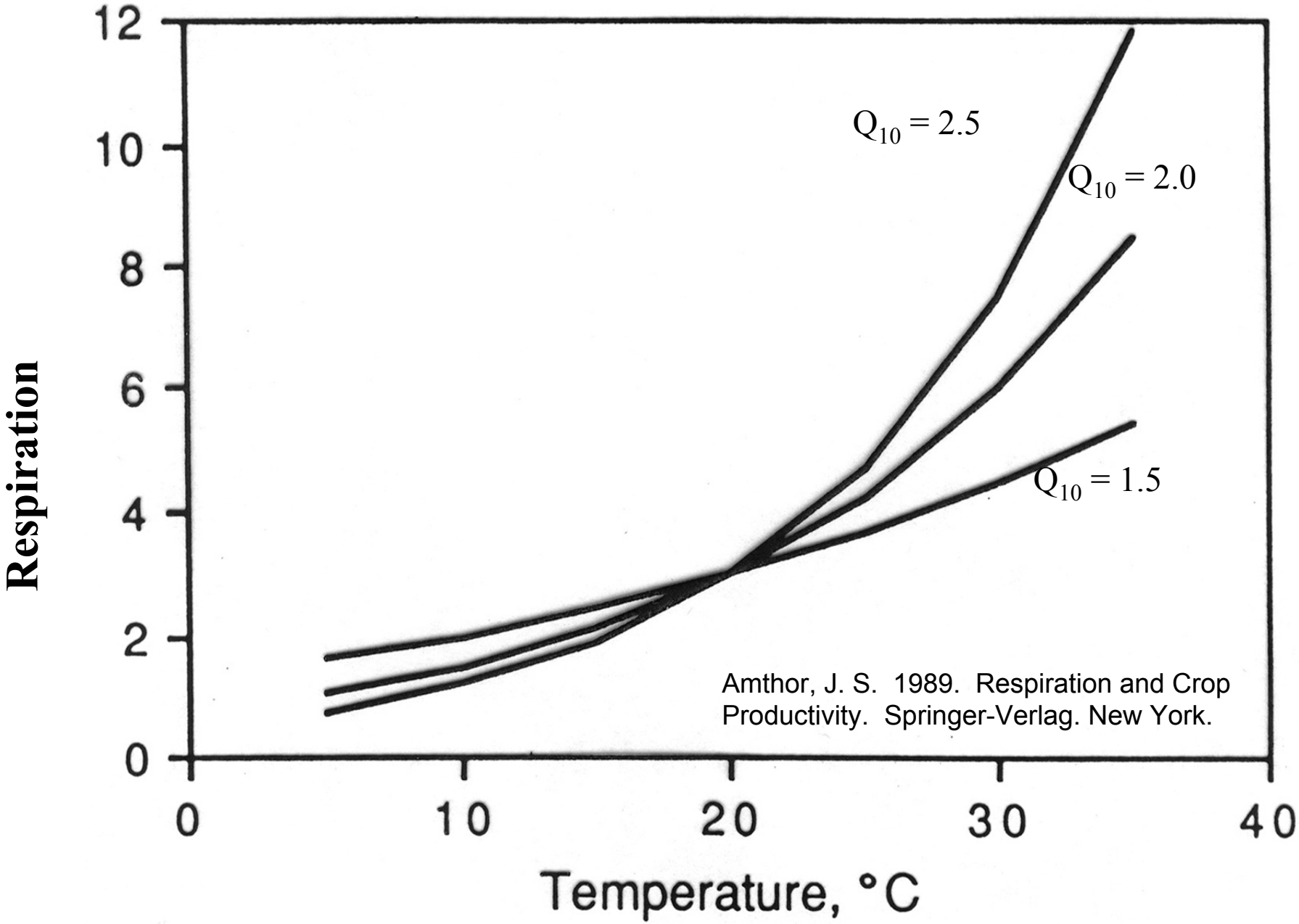
"Respiration typically increases with temperature…Between 0 and 30^{o}C, the increase in respiration rate for every 10^{o}C increase in ambient temperature (commonly referred to as the dimensionless, temperature coefficient, Q_{10}) is about 2."


Respiration
12
10
8
6
4
2
0
0
10
20
30
40
Temperature, °C
Q_{10} = 2.5
Q_{10} = 2.0
Q_{10} = 1.5
Amthor, J. S. 1989. Respiration and Crop Productivity. Springer-Verlag. New York.

Organism	Q_{10}
microbes	1.4 to 1.6
pine	1.8
camphor tree	1.6 to 2.7
ants	2.4
maple	2.7
* marigold	1.3 to 2.5
* lettuce	1.2 to 1.7

Classic View of Respiration

Total Respiration = growth + maintenance

Growth

Dependent on type of biomass and new growth

Maintenance

Dependent on temperature and existing biomass

Organism	Q_{10}
microbes	1.4 to 1.6
pine	1.8
camphor tree	1.6 to
ants	2.4
maple	2.7
* marigold	1.3 to 2.5
* lettuce	1.2 to 1.7

Often in reference to total respiration

Total Respiration = growth + maintenance

- **What fraction of growth and maintenance?**
  - Rate of growth
  - Age of plant
  - Season

Total Respiration = growth + maintenance

- **What fraction of growth and maintenance?**
  - Rate of growth
  - Age of plant
  - Season

- **How were the studies performed?**
  - Plant part
  - Length of time
  - Change in temperature

Organism	Q_{10}	comments
microbes	1.4 to 1.6	Rapid growth
pine	1.8	Dormant in NC
camphor tree	1.6 to 2.7	Summer to winter
ants	2.4	‘headless’ system
maple	2.7	Dormant in MI
*marigold	1.3 to 2.4	
*lettuce	1.2 to 1.7	

Organism	Q_{10}	comments
microbes	1.4 to 1.6	Rapid growth
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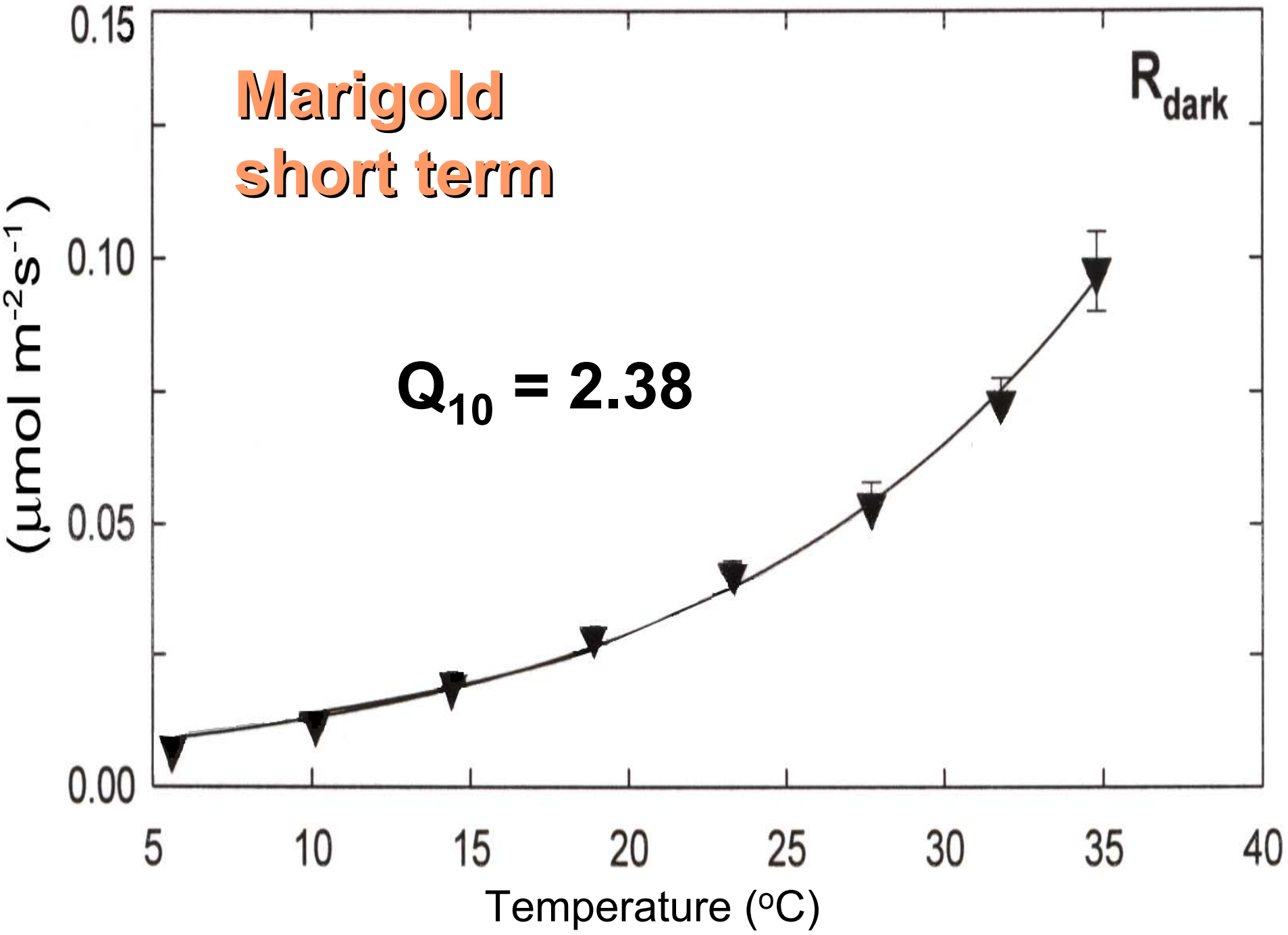
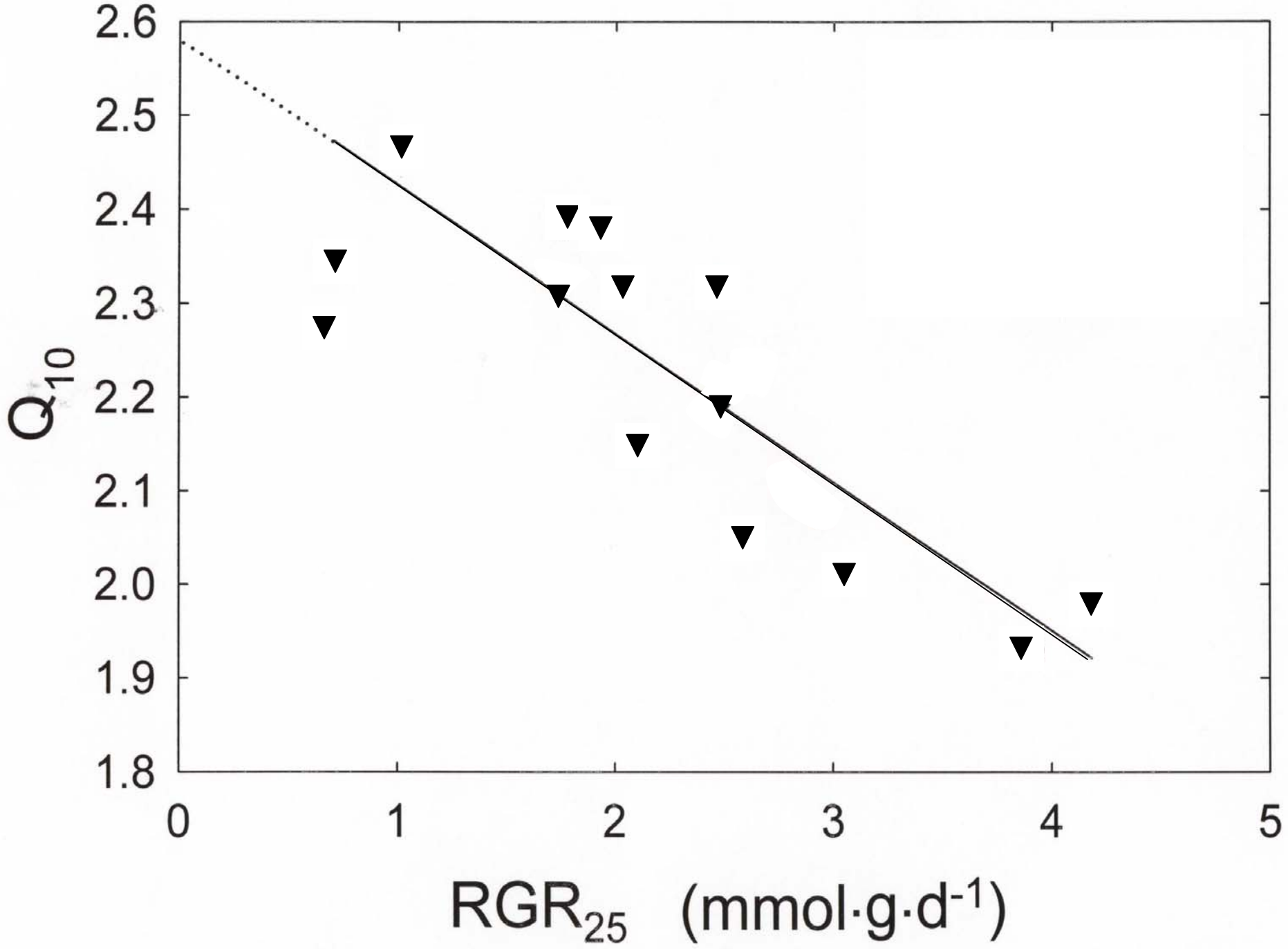
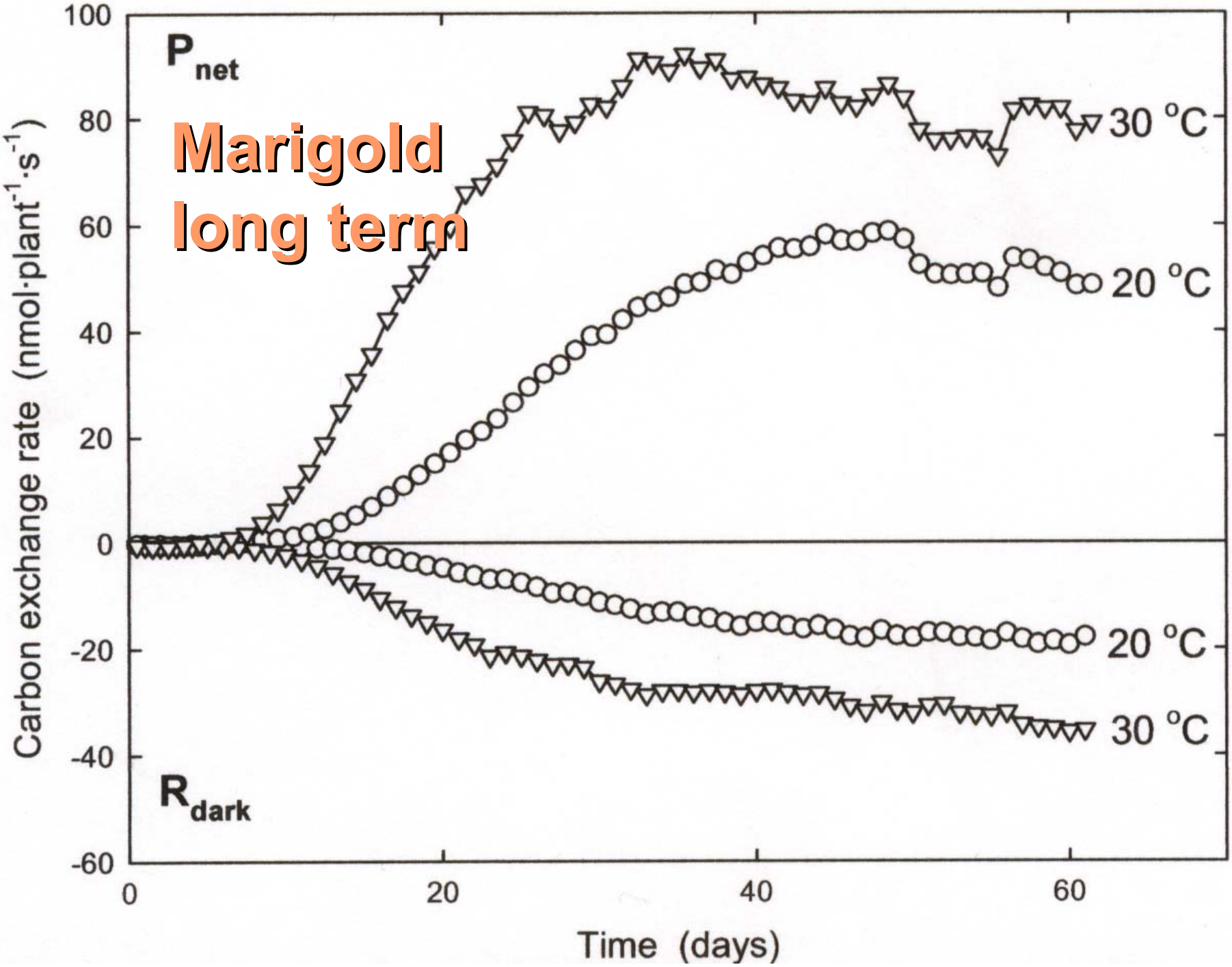
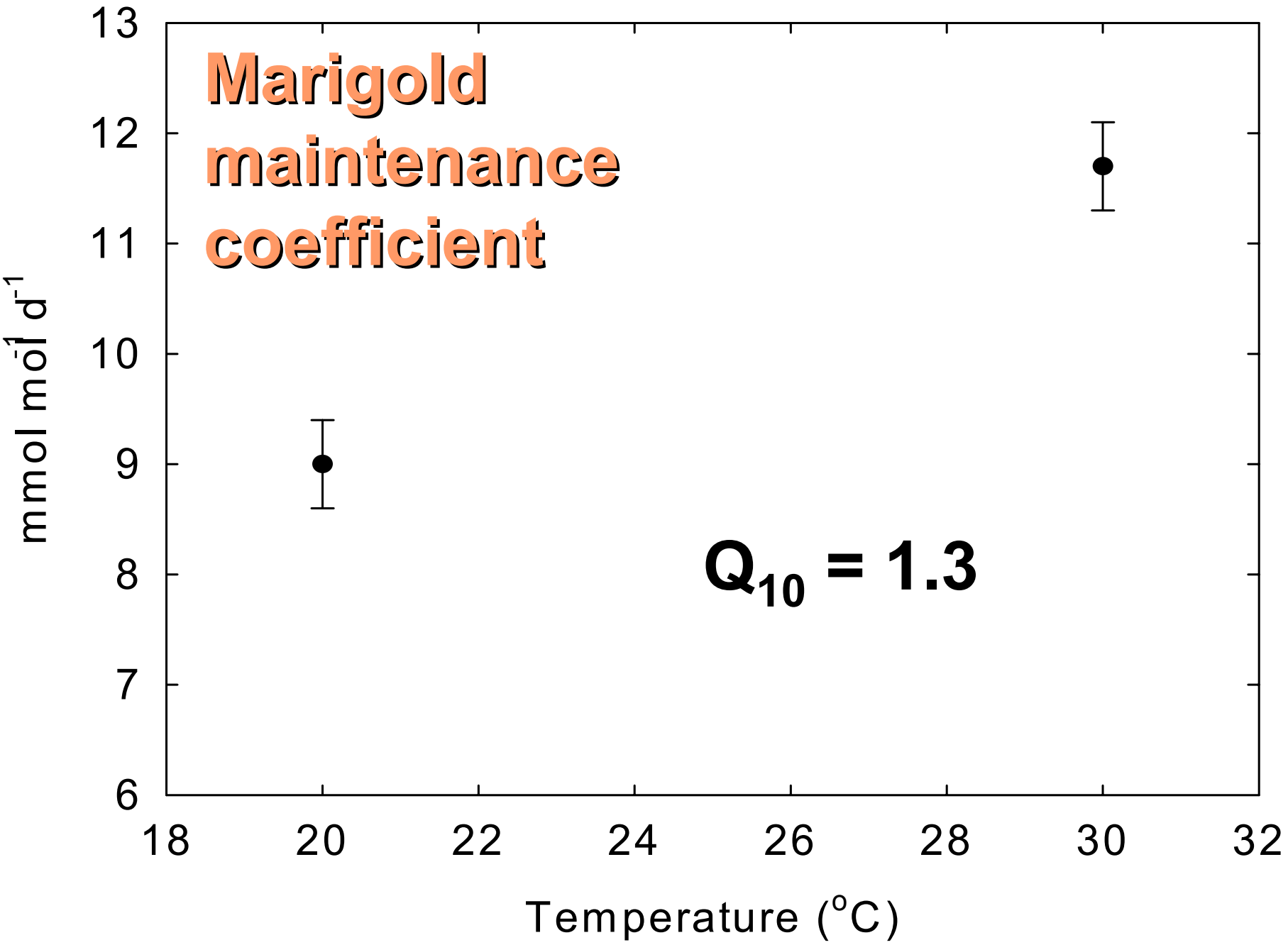
camphor tree	1.6 to 2.7	Summer to winter
ants	2.4	‘headless’ system
maple	2.7	Dormant in MI
*marigold	1.3 to 2.4	Whole canopy
*lettuce	1.2 to 1.7	Whole canopy


Marigold
short term
R_{dark}
Q_{10} = 2.38
(µmol $m^{-2}s^{-1}$)
0.15
0.10
0.05
0.00
5
10
15
20
25
30
35
40
Temperature (°C)

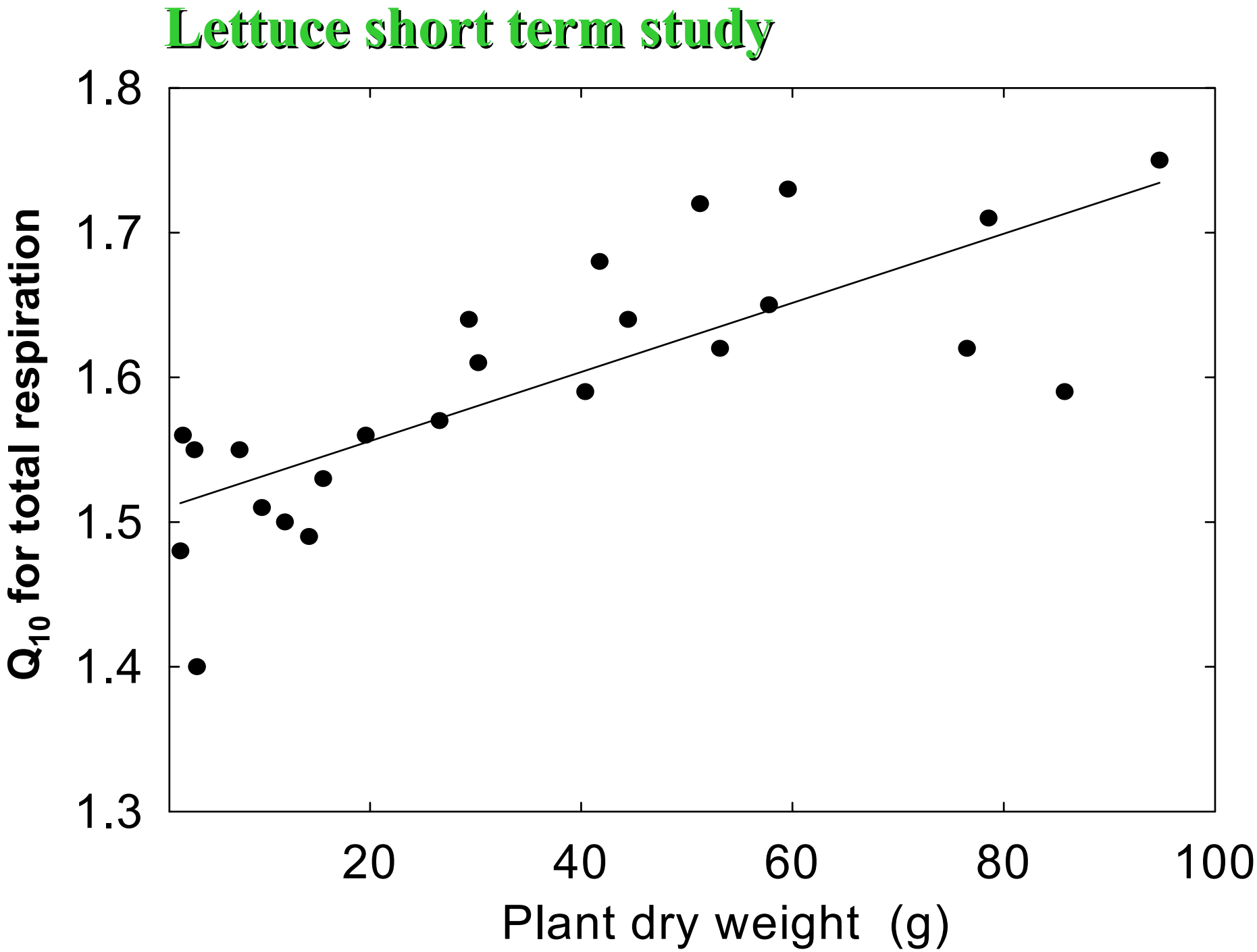

2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
Q_{10}
0
1
2
3
4
5
RGR_{25} (mmol·g·d^{-1})


Marigold
long term
P net
R dark
30 °C
20 °C
20 °C
30 °C
Carbon exchange rate (nmol·plant-1·s-1)
Time (days)
100
80
60
40
20
0
-20
-40
-60
0
20
40
60

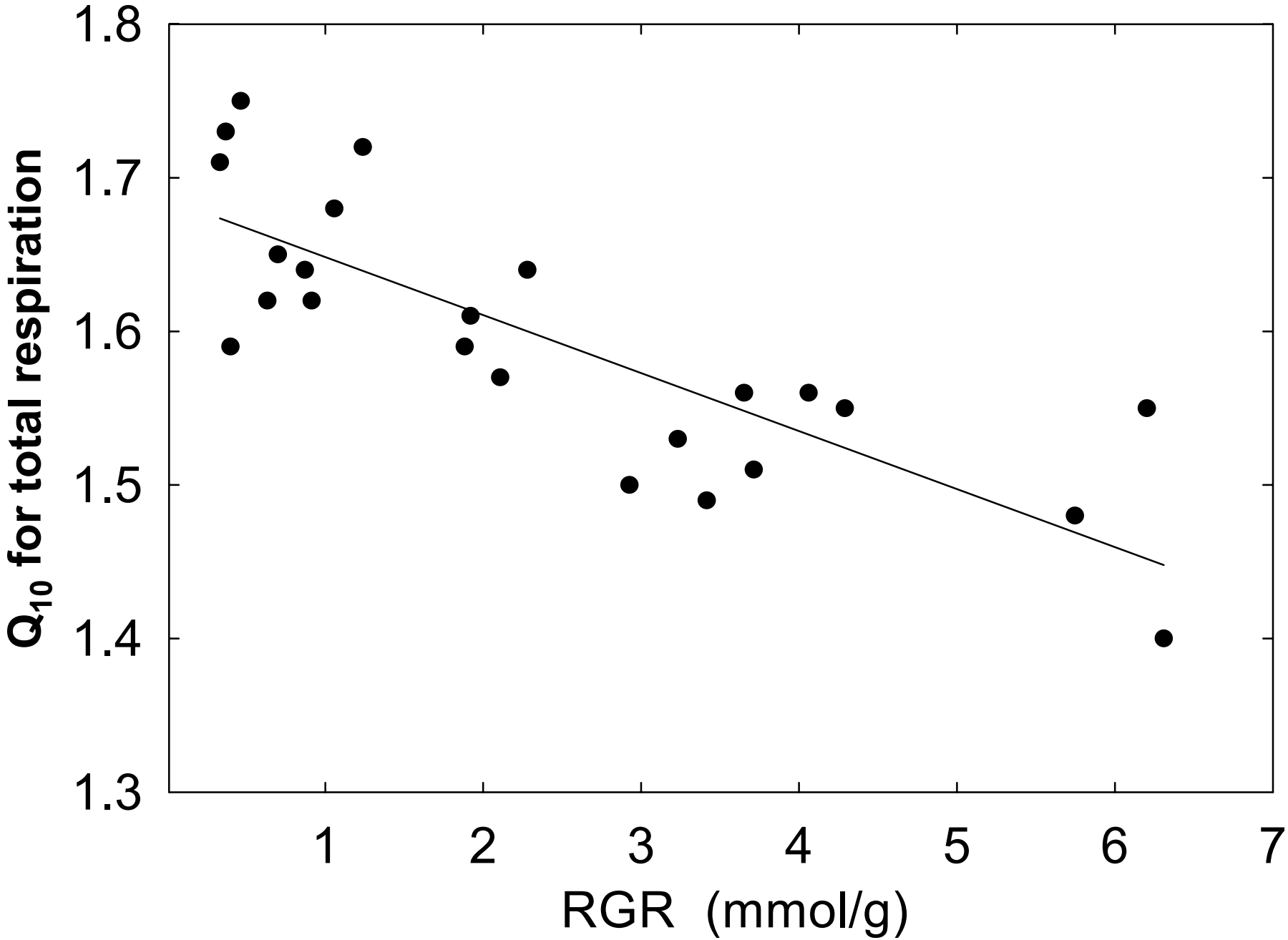

Marigold
maintenance
coefficient
Q_{10} = 1.3
mmol mol^{-1} d^{-1}
Temperature (^{o}C)
13
12
11
10
9
8
7
6
18
20
22
24
26
28
30
32

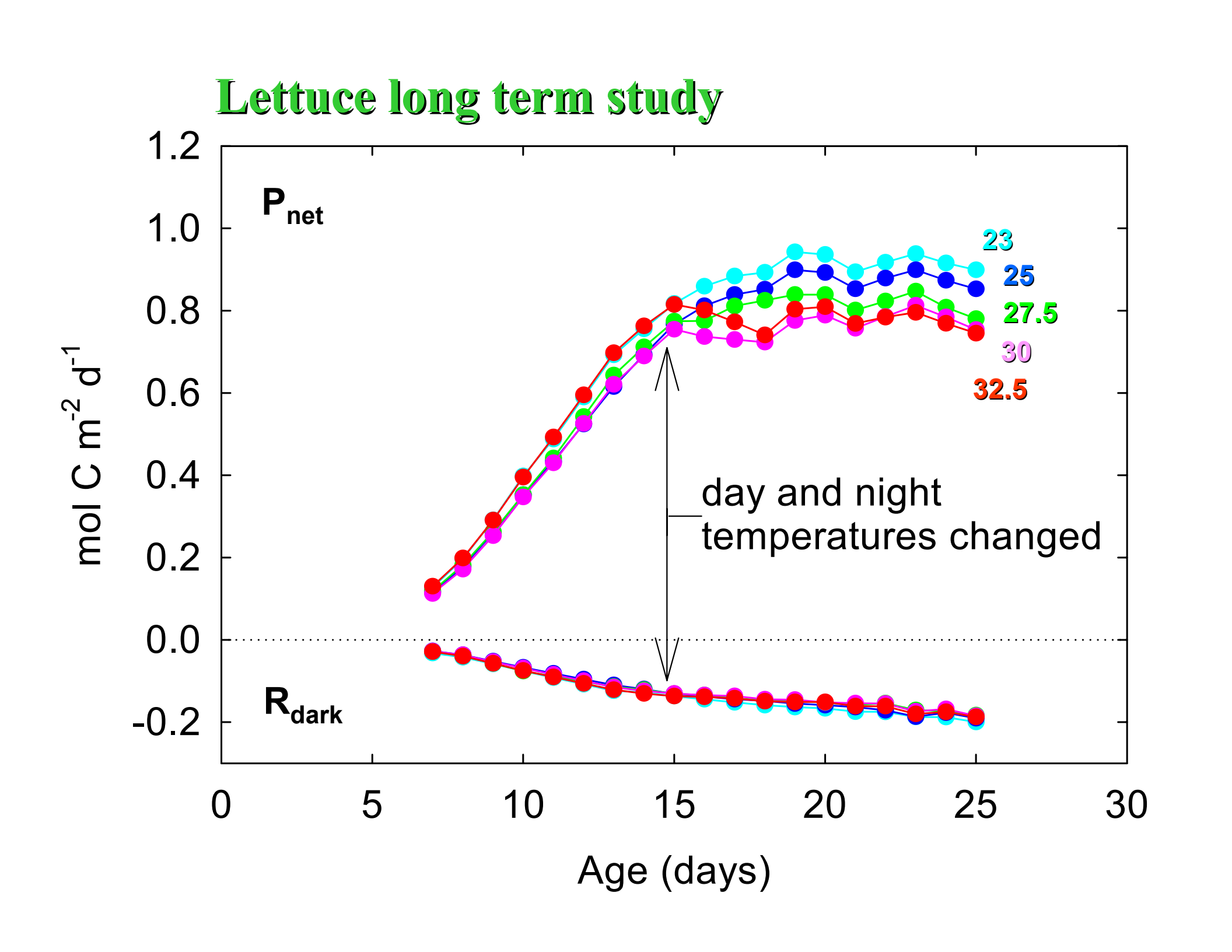
- **What fraction of growth and maintenance?**
  - Rate of growth — wide range
  - Age of plant — wide range
  - Season

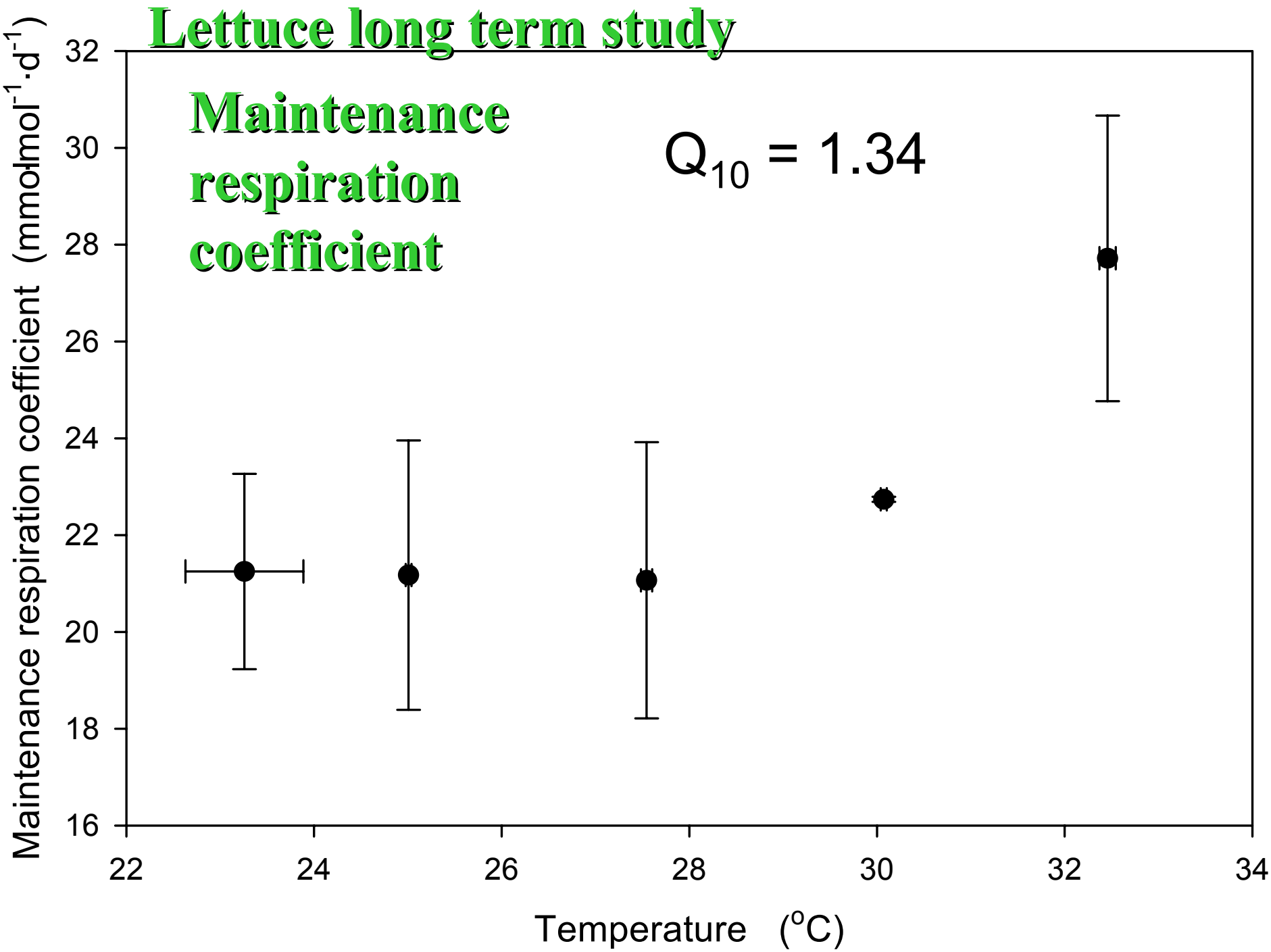
- **How were the studies performed?**
  - Plant part — canopy
  - Length of time — long vs short term
  - Change in temperature — none vs 30C


Lettuce short term study
1.8
1.7
1.6
1.5
1.4
1.3
Q_{10} for total respiration
20
40
60
80
100
Plant dry weight (g)

Lettuce short term study

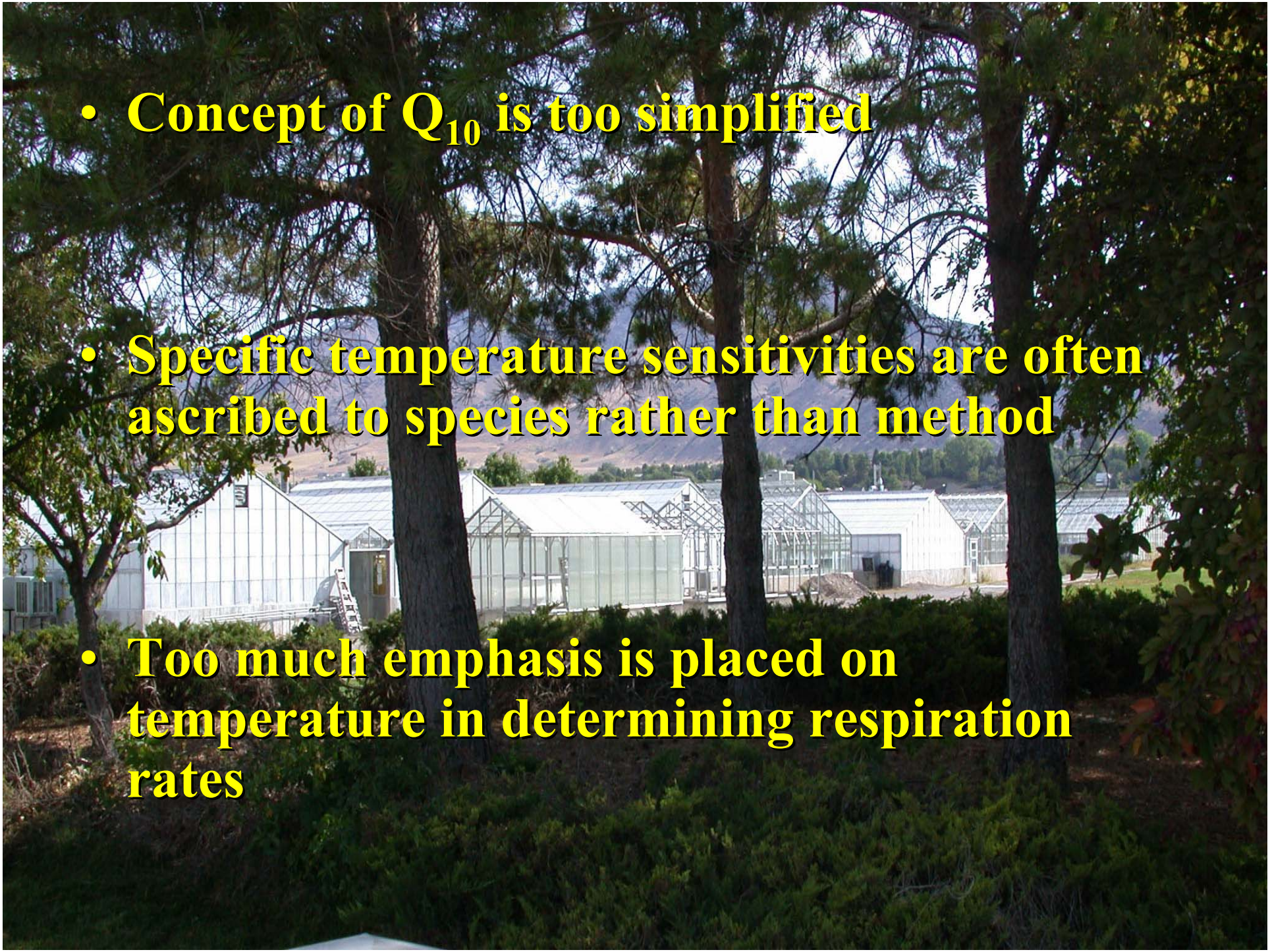



Lettuce long term study
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
mol C m-2 d-1
Pnet
Rdark
23
25
27.5
30
32.5
day and night
temperatures changed
0
5
10
15
20
25
30
Age (days)


Lettuce long term study
Maintenance respiration coefficient
Q_{10} = 1.34
Maintenance respiration coefficient (mmol·mol^{-1}·d^{-1})
32
30
28
26
24
22
20
18
16
22
24
26
28
30
32
34
Temperature (°C)

- **What fraction of growth and maintenance?**
  - Rate of growth — wide range
  - Age of plant — wide range
  - Season

- **How were the studies performed?**
  - Plant part — canopy
  - Length of time — long vs short term
  - Change in temperature — once vs 30C


• Concept of Q_{10} is too simplified
• Specific temperature sensitivities are often ascribed to species rather than method
• Too much emphasis is placed on temperature in determining respiration rates